

WHAT IS CLAIMED IS:

1. A traffic shaping apparatus for controlling an allowed transmission frame rate of user frames according to frame rates specified in advance, for each user who transmits and receives the user frames through a network, the traffic shaping apparatus comprising:

a plurality of frame queues, each provided for a corresponding user, for storing the user frames of the corresponding user;

a frame-rate storage section for storing a minimum transmission frame rate and a peak transmission frame rate specified for each user;

a transmission-interval calculation section for calculating an allowed transmission frame rate of user frames for each user by using the minimum transmission frame rate or the peak transmission frame rate, for calculating a reference transmission interval of the user frames for each user by using the calculated allowed transmission frame rate, and for calculating a minimum transmission interval for each user by using the peak transmission frame rate;

a transmission-interval storage section for storing the reference transmission interval and the minimum transmission interval for each user;

a time calculation section for calculating a first estimated transmission time for each user by using the reference transmission interval and for calculating a second estimated transmission time for each user by using the minimum transmission interval;

a time storage section for storing the first estimated transmission time and the second estimated transmission time for each user;

5 a determination section for determining the user having the earliest first estimated transmission time among one or more users corresponding to one or more frame queues where at least one user frame is stored, and for determining whether a user frame is to be transmitted according to the second estimated
10 transmission time for the determined user;

a frame reading section for reading the user frame from the frame queue corresponding to the determined user when the determination section has determined that the user frame of the determined user is to be
15 transmitted; and

a transmission section for transmitting the read user frame.

2. A traffic shaping apparatus according to Claim 1,
20 wherein the transmission-interval calculation section calculates the minimum transmission interval when the peak transmission frame rate is specified for each user, periodically calculates the allowed transmission frame rate and the reference transmission
25 interval for each user, and stores them in the transmission-interval storage section.

3. A traffic shaping apparatus according to Claim 1,
wherein the frame-rate storage section further
30 stores the maximum frame rate of a line through which a

user frame of each user is transmitted, and

the transmission-interval calculation section calculates the allowed transmission frame rate for each user by using the maximum frame rate of the line and the
5 minimum transmission frame rate.

4. A traffic shaping apparatus according to Claim 3,
wherein the transmission-interval calculation
section calculates the allowed transmission frame rate
10 for each user according to the following expression:

Allowed transmission frame rate of user = (maximum
frame rate of the line through which a user frame of the
user is to be transmitted) x (minimum transmission frame
rate specified for the user)/(sum of minimum
15 transmission frame rates of active users who transmit
user frames through the line).

5. A traffic shaping apparatus according to Claim 1,
wherein the transmission-interval calculation
20 section calculates the reference transmission interval
for each user according to the following expression:

Reference transmission interval of user = (maximum
frame rate which the traffic shaping apparatus can
control)/(allowed transmission frame rate for the user).
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6. A traffic shaping apparatus according to Claim 1,
wherein the transmission-interval calculation
section calculates the minimum transmission interval for
each user according to the following expression:

30 Minimum transmission interval of user = (maximum

frame rate which the traffic shaping apparatus can control)/(maximum transmission frame rate for the user).

7. A traffic shaping apparatus according to Claim 1,
5 wherein the determination section instructs the time calculation section to calculate times when the determination section has determined that the user frame of the determined user is to be transmitted, and

10 the time calculation section calculates the first estimated transmission time and the second estimated transmission time for the determined user and stores them in the time storage section when the time calculation section is instructed by the determination section.

15 8. A traffic shaping apparatus according to Claim 7, wherein the time calculation section calculates the first estimated transmission time and the second estimated transmission time for each user according to
20 the following expressions:

First estimated transmission time = previous estimated transmission time + reference transmission interval for the user, and

25 Second estimated transmission time = previous estimated transmission time + minimum transmission interval for the user.

9. A traffic shaping apparatus according to Claim 1,
30 wherein the determination section determines that a user frame is to be transmitted when the second

estimated transmission time for the determined user matches the current time or indicates a time in the past compared with the current time.

5 10. A traffic shaping apparatus according to Claim 1, further comprising:

 a receiving section for receiving a user frame;

 an identification section for identifying the user for whom the user frame is to be transmitted or received,
10 according to information included in the user frame; and

 a frame storage section for storing the user frame in the frame queue corresponding to the identified user.

15 11. A traffic shaping apparatus according to Claim 10,

 wherein the identification section determines whether the user frame has been received in a state in which there is no user frame in the frame queue corresponding to the identified user, and when the
20 identification section determines that the user frame has been received in said state, the identification section instructs the time calculation section to calculate times, and

 the time calculation section calculates the first
25 estimated transmission time and the second estimated transmission time for the identified user and stores them in the time storage section when the time calculation section is instructed by the determination section.

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12. A traffic shaping apparatus according to Claim 11,

wherein the time calculation section calculates the first estimated transmission time and the second
5 estimated transmission time for each user according to the following expressions:

First estimated transmission time = current time + reference time, and

Second estimated transmission time = current time +
10 reference time.

13. A traffic shaping method for controlling an allowed transmission frame rate of user frames according to frame rates specified in advance, for each user who
15 transmits and receives the user frames through a network, the traffic shaping method comprising the steps of:

setting a minimum transmission frame rate and a peak transmission frame rate for each user;
calculating a minimum transmission interval for each
20 user by using the peak transmission frame rate;
calculating an allowed transmission frame rate of user frames for each user by using the minimum transmission frame rate or the peak transmission frame rate;
calculating a reference transmission interval of the
25 user frames for each user by using the allowed transmission frame rate;
calculating a first estimated transmission time for each user by using the reference transmission interval;
calculating a second estimated transmission time for
30 each user by using the minimum transmission interval;

receiving a user frame for each user and storing it
in association with the user;

determining the user having the earliest first
estimated transmission time among one or more users for
5 whom at least one user frame is stored;

determining whether a user frame is to be transmitted
according to the second estimated transmission time of
the determined user; and

transmitting the user frame of the determined user
10 when it has been determined that the user frame of the
determined user is to be transmitted.

14. A traffic shaping method according to Claim 13,
wherein, in the step of calculating the minimum
15 transmission interval, the minimum transmission interval
is calculated when the peak transmission frame rate is
specified for each user.

15. A traffic shaping method according to Claim 13,
20 wherein, in the steps of calculating the allowed
transmission frame rate and the reference transmission
interval, the allowed transmission frame rate and the
reference transmission interval are periodically
calculated for each user.

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16. A traffic shaping method according to Claim 13,
wherein, in the steps of calculating the allowed
transmission frame rate, the reference transmission
interval, and the minimum transmission interval,
30 the allowed transmission frame rate, the reference

transmission interval, and the minimum transmission interval are calculated for each user according to the following expressions:

Allowed transmission frame rate of user = (maximum
5 frame rate of the line through which a user frame of the user is to be transmitted) x (minimum transmission frame rate specified for the user)/(sum of minimum transmission frame rates of active users who transmit user frames through the line),

10 Reference transmission interval of user = (maximum frame rate which the traffic shaping apparatus can control)/(allowed transmission frame rate for the user), and

15 Minimum transmission interval of user = (maximum frame rate which the traffic shaping apparatus can control)/(maximum transmission frame rate for the user).

17. A traffic shaping method according to Claim 13,
wherein, in the step of transmitting the user frame,
20 the first estimated transmission time and the second estimated transmission time of the determined user are further calculated.

18. A traffic shaping method according to Claim 17,
25 wherein, in the steps of calculating the first estimated transmission time and the second estimated transmission time, the first estimated transmission time and the second estimated transmission time are calculated according to the following expressions:

30 First estimated transmission time = previous

estimated transmission time + reference transmission interval for the user, and

Second estimated transmission time = previous estimated transmission time + minimum transmission
5 interval for the user.

19. A traffic shaping method according to Claim 13, wherein, in the step of determining whether the user frame is to be transmitted, it is determined that the
10 user frame is to be transmitted when the second estimated transmission time of the determined user indicates the current time or a time in the past compared with the current time.

15 20. A relay apparatus connected to a plurality of lines, for relaying frames between the lines, comprising:

a plurality of interface sections each connected to at least one of the plurality of lines, for transmitting
20 and receiving a frame to and from the line, the plurality of interface sections each comprising a frame buffer for temporarily storing the frame;

a relay section connected to the plurality of interface sections, for determining the interface
25 section connected to a line through which the frame is to be transmitted, according to header information included in a frame received by the each interface sections, and for relaying the frame to the determined interface section; and

30 a traffic shaping apparatus connected to at least

one of the plurality of interface sections and to the relay section, for controlling an allowed transmission frame rate according to frame rates specified in advance, for each user who transmits and receives a frame through
5 a line, and for transmitting a frame,
the traffic shaping apparatus having:

a frame-rate storage section for storing a minimum transmission frame rate and a peak transmission frame rate specified for each user;

10 a transmission-interval calculation section for calculating an allowed transmission frame rate of frames for each user by using the minimum transmission frame rate or the peak transmission frame rate, for calculating a reference transmission interval of the
15 frames for each user by using the calculated allowed transmission frame rate, and for calculating a minimum transmission interval for each user by using the peak transmission frame rate;

a transmission-interval storage section for
20 storing the reference transmission interval and the minimum transmission interval for each user;

a time calculation section for calculating a first estimated transmission time for each user by using the reference transmission interval and for calculating a
25 second estimated transmission time for each user by using the minimum transmission interval;

a time storage section for storing the first estimated transmission time and the second estimated transmission time for each user;

30 a determination section for determining the user

having the earliest first estimated transmission time among one or more users for whom at least one frame is stored in the frame buffer, and for determining whether a frame is to be transmitted according to the second
5 estimated transmission time of the determined user;

a frame reading section for reading the frame of the determined user from the frame buffer when the determination section has determined that the frame of the determined user is to be transmitted; and

10 a transmission section for transmitting the read frame to one of the lines through one of the plurality of interface sections.